

On the Spectra of Ordinary Lead and Lead of Radioactive Origin.

By THOMAS R. MERTON, B.Sc. (Oxon.).

(Communicated by A. Fowler, F.R.S. Received December 21, 1914.)

The view that the spectra of isotopes are identical was first put to the test by Russell and Rossi* and Exner and Haschek,† who examined the spectra of thorium and ionium preparations. The former of these observers worked with a mixture containing at least 10 per cent. of ionium, but no lines were found which were not present in the spectrum of pure thoria.

Aston‡ has submitted neon to fractional diffusion, by which a [partial separation was effected, as shown by the change of density, but no change in the spectrum was observed.

More recently Soddy and Hyman§ and Richards and Lambert|| have compared the spectrum of lead of radioactive origin with that of ordinary lead. The former of these investigators, who worked with lead from thorite, found that the line $\lambda = 4760.1$ was stronger in ordinary lead than in the thorite lead, but that the spectra in other respects appeared to be identical. Richards and Lambert also found that the spectra were identical. In both of these investigations, the Féry spectrograph was used for the photography of the spectra; no details are given, but it is presumed that in both cases the spectra of the radioactive and ordinary lead were photographed in juxtaposition on the same plate.

This method is admirably suited to a general comparison, but it gives no numerical data as to the exact degree of identity of the wave-lengths in the two spectra.

It might reasonably be expected that in the spectra of isotopes small differences of wave-length would occur, though the character and distribution of the lines were the same.

According to the recent views of Prof. Hicks, an atomic weight term enters exactly into the separations of doublets and triplets in series spectra. No series have yet been found for the spectrum of lead, but Kayser and Runge¶

* 'Roy. Soc. Proc.,' vol. 87, p. 478 (1912).

† 'Sitzungsber. K. Akad. Wiss. Wien,' vol. 121 (2 Abth.), p. 175 (1912).

‡ British Association Meeting, 1913.

§ 'Chem. Soc. Trans.,' vol. 105, p. 1402 (1914).

|| 'Amer. Chem. Soc. Journ.,' vol. 36, p. 1329 (1914).

¶ 'Wied. Ann.,' vol. 52, p. 93 (1894).

have found that a group of ten lines repeats itself three times with constant frequency differences. It seems probable, however, that doublet or triplet series exist in the lead spectrum, and for the lines which fall into such series there should, according to the views of Prof. Hicks, be differences of wave-length in the two isotopes corresponding with the difference of atomic weight.

In the present investigation, I have made a comparison of the wave-lengths of some of the most prominent lines in the spectrum of ordinary lead and of the lead in Joachimsthal pitchblende. The spectra were photographed with a concave grating spectrograph, mounted according to the arrangement of Eagle* and provided with a concave grating of 4 feet radius of curvature having 20,000 lines to the inch. The plates were measured on a Hilger micrometer.

The spectra were produced in the carbon arc, the carbons being cored, as the case might be, with the pitchblende residues or with iron oxide containing a small proportion of ordinary lead. The residues contained a considerable quantity of iron which served as a comparison spectrum. A number of plates were taken, in which the two spectra were in juxtaposition, and the lines due to lead were found to be identical in the two spectra.

The object of the present investigation, however, is to set some superior limit to any wave-length differences that might occur.

The wave-lengths of the principal lead lines between $\lambda = 3500$ and $\lambda = 4100$ have therefore been independently measured in the ordinary and radioactive lead spectra, the iron lines being used as standards. The values obtained are given in the following table:—

λ , ordinary lead.	λ , lead from residues.	λ , ordinary lead— λ , lead from residues.	λ , Kayser.
*3572·88	3572·88	$\pm 0\cdot00$	3572·88
3639·72	3639·69	$+ 0\cdot03$	3639·71
*3671·66	3671·64	$+ 0\cdot02$	3671·65
3683·59	3683·60	$- 0\cdot01$	3683·60
*3740·08	3740·06	$+ 0\cdot02$	3740·10
4057·98	4057·99	$- 0\cdot01$	4057·97
4062·31	4062·33	$- 0\cdot02$	4062·30

The dispersion was about 10 Å.U. per millimetre and the differences observed, which are not systematic, are within the experimental error, and it may therefore be concluded that no differences greater than $0\cdot03$ Å.U. occur in these lines. The three lines marked with an asterisk are members of the groups of ten, discovered by Kayser and Runge (*loc. cit.*).

* 'Astrophys. Journ.,' vol. 31, 2, p. 120 (1910).

The atomic weight determinations of Richards and Lemberg (*loc. cit.*), Honigschmid and Horovitz* and Curie† show that the atomic weight of lead from the pitchblende residues is somewhat greater than the value predicted by theory, this being no doubt due to the presence of a small quantity of ordinary lead in the pitchblende. If the spectrum lines in the two leads differed in wave-length by a small amount, the lines from the pitchblende residues would be double. If the components were not resolved in the spectroscopic, the doubling should nevertheless make itself felt as an apparent shift or an asymmetric broadening of the line. On the assumption that the lead in my residues has an atomic weight about 5 unit less than ordinary lead, Prof. J. W. Nicholson has very kindly calculated for me the order of the change of wave-length to be expected according to Prof. Hicks' theory, in the case of lines belonging to series, doublets or triplets.

If the separation of two such lines in a doublet were 50 Å.U. at $\lambda = 4000$ Å.U. (an order of separation which might reasonably be expected to occur in the case of lead doublets), then a change of atomic weight of 0.5 unit should alter the separation of the lines by about 0.3 Å.U., or if each of the lines were shifted by an equal amount, a change of wave-length of the order of 0.15 Å.U. in each line would result.

It may be stated with certainty that in the lead lines, which are not given in the above list but which were observed in the photographs of the spectra taken in juxtaposition, no change of wave-length of this order occurs.

A special examination has been made of the line $\lambda = 4058$. This line is by far the strongest line which can be photographed through glass lenses and prisms. The comparison has been made of this line in the two lead spectra by photographing the ring systems produced by means of a Fabry and Perot étalon. The line $\lambda = 4058$, when produced in the carbon arc at atmospheric pressure, is too broad for the production of interference rings of sufficiently good definition. The spectrum was therefore produced in a glass globe of about 1 litre in capacity, exhausted by means of a Fleuss pump to a pressure of a few millimetres of mercury, between carbon rods, cored with small quantities of the two leads as carbonates or oxides. Under these conditions sharp definition could be obtained. The convergent beam of light from a lens placed at a suitable distance from the arc passed through the étalon, and an achromatic lens of 6 inches focal length brought the ring system to a focus on the slit of a large Hilger constant-deviation spectroscopic provided with a camera attachment. The étalon consisted of two half-silvered plane parallel glass plates separated by three glass studs, the distance between the

* 'Comptes Rendus,' vol. 158, p. 1796 (1914).

† 'Comptes Rendus,' vol. 158, p. 1676 (1914).

plates being 6.50 mm. The exposures were made within two or three minutes of one another, to avoid variations due to changes of temperature.

Photographs taken in this way showed that the interference rings are identical for the two lead spectra, and measurements of the diameters of the rings agree within the limits of experimental error, the calculated results showing that there is certainly no difference of wave-length for the line $\lambda = 4058$ as great as 0.003 Å.U. in the spectrum of ordinary lead and of the lead from pitchblende.

In conclusion, I should like to thank Prof. Nicholson for the calculation which he has made for me.

On the Viscosity of the Vapour of Iodine.

By A. O. RANKINE, D.Sc., Fellow of and Assistant in the Department of
Physics in University College, London.

(Communicated by Prof. A. W. Porter, F.R.S. Received January 15, 1915.)

In a previous communication* I have described the measurements I have made of the viscosity of bromine vapour. The method used for this purpose involved the distillation of bromine from one vessel to another through a capillary tube. The pressure difference between the two ends of the capillary was established by maintaining the two vessels at suitable different temperatures, and the rate of transpiration of the bromine vapour was estimated by observing the volume of the liquid bromine which evaporated in a given time. It was hoped that the same method could be applied to iodine by adjusting the temperatures of evaporation and condensation to values above the melting point of iodine (113° C.), and measuring the transpiration rate by means of the disappearance of liquid from the evaporation vessel.

Preliminary experiments, however, soon revealed the fact that the liquid iodine was not sufficiently mobile, and its surface was too indefinite and variable in shape to allow small changes of volume to be observed. It was, therefore, found necessary to modify in several respects the method used with bromine.

The present paper describes the modified method, which was found to work extremely well and to give very consistent results. Values of the viscosity of

* 'Roy. Soc. Proc.,' A, vol. 88, pp. 575-588 (1913).